Title

Ten Years Later: Examining the Long-Term Impact of the California Safe Routes to School Program

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ABSTRACT
California was the first state to legislate a Safe Routes to School (SR2S) program under Assembly Bill AB 1475 (1999). SR2S funds construction projects that make it safer for children to walk/bicycle to school and encourage a greater number of children to choose these modes of travel for the school commute. The main goal of this project was to assess the long-term impact of program-funded engineering modifications on walking/bicycling levels and on safety. Evaluation of improvements was determined using a targeted method of determining the countermeasures to result in safety and mode shift. Major results indicate that safety of pedestrians increased within 250 feet of an infrastructure improvement, such as a sidewalk. There was also evidence of mode shift near improvements, as well. Positive results for safety and mobility, as well as improved data collection for funded programs, should make Safe Routes to School programs competitive among other transportation needs.

INTRODUCTION

For over 10 years, efforts to encourage children to walk and bicycle to school have attracted concerted programmatic and policy attention to address the issues of physical inactivity and pedestrian injury risk around schools and in the local community in the United States (*1*). In 1969, 42 percent of US schoolchildren aged five to eighteen walked or bicycled to school. By 2009, this number had declined to 12.7 percent (*2*).

A 2008 report from the CDC investigating why more children do not walk to school found traffic safety to be the second most common barrier (*3*). Overall, children are involved in about one-third of all pedestrian-vehicle crashes (*4*). Children aged 5-15 bicycle more than any other age group. In 2011, children under the age of 16 comprised 21 percent of those injured and 11 percent of those killed in a bicycle crash *(5).*

Research on the barriers and opportunities to walk and bicycle to school consistently find that distance between home and school is a primary factor influencing how children travel to school (6,*7,8,9,10,11,12,13,14,15,16,17*). A study of sixteen California elementary schools participating in the California Safe Routes to School project found that children that lived within a mile of school were three times more likely to walk to school than to travel by private vehicle (*13*).

Engineering-related factors that increase pedestrian and bicycle safety may also influence walking and bicycling to school. Separating pedestrians/bicyclists and motor vehicles onto different elements of the transportation system; e.g., providing sidewalks, bike lanes and bike paths, reducing conflict points between pedestrian/bicyclists and motor vehicles; e.g., providing marked crosswalks, crossings at traffic lights and altering the signal timing so there is a pedestrian-only phase and reducing traffic volumes and speeds around schools are possible areas of engineering modification. A study of nineteen elementary schools in Australia found that children were less likely to walk or bicycle to school if they had to travel along a roadway with busy traffic and no lights or crossing points (*15*). At three elementary schools in California, parents reported a 38 percent increase in how often children walked to school after a SRTS sidewalk improvement was completed (*19*).

Safe Routes to School (SR2S) is a program that initially developed in Odense, Denmark in the 1970s after studies revealed that Denmark had the highest child pedestrian collision rate in Europe. The Odense program created a series of engineering improvements to reduce safety hazards. Ten years after implementation, child pedestrian casualties decreased by more than 80 percent (*20*). The first program in the U.S. was initiated in 1994 in the Bronx, New York. Like the Odense program, this community SR2S program focused primarily on reduction of pedestrian injury and death through engineering improvements.

In 1999, California became the first state to pass legislation for a state level program, which allocated federal transportation funds for engineering modifications near schools. The goals of the policy are to increase walking and bicycling activity among students at elementary, middle and high schools and to reduce child/adolescent injuries and fatalities. The dual programs goals are key – focusing on safety as well as mobility means that broader public health goals can be attained than just focusing on mobility or safety alone. Subsequently, federal funds were made available to schools through the Safe Routes to School project allocated by SAFETEA-LU, the transportation authorization in place between 2005-2010. The acronym of the federal program, SRTS, will be used throughout the rest of this paper for the sake of clarity.

The California program provides funding to municipalities for engineering modifications such as sidewalks, crosswalk placement & painting, traffic lights or speed humps near schools.

The municipality is required to provide a minimum of 10% in local matching funds. Since its inception in 1999 to the end of 2006, the California SRTS program funded 570 projects with a total cost of over $190 million. The projects have been equitably distributed across the state, with proportional representation achieved geographically and by population (*21*).The California legislature has re-authorized the program three times over the past decade.

The original California legislation included mandates for two periods of evaluation to measure any changes in 1) mobility and 2) safety. A research team from the University of California, Irvine (UCI) conducted the first study, which focused on the impact of the program on levels of walking and bicycling to school and traffic safety characteristics (e.g., vehicle speeds, yielding, pedestrian and bicyclist travel patterns) near school (*22,23)*. In the second evaluation, a research team from the University of California, Berkeley (*21*) examined the effectiveness of the program in reducing crashes, injuries and fatalities involving children in the vicinity of the projects (*21*). The UCI evaluation collected pre and post construction data at 10 schools and found increased rates of walking and bicycling to school after the engineering modification was completed near a school, particularly when the modification was along a child's chosen route to school. Additionally, this evaluation found that traffic safety conditions improved at several schools, such as children walking on a newly constructed sidewalk rather than the shoulder of the roadway and yielding rates of motor vehicles to pedestrians and bicyclists at intersections after the installation of a traffic signal (*22,23*). The UCB evaluation, which examined 125 California SRTS projects funded between 2000-2005, found an overall decline in the number of child pedestrian/bicyclist injuries in the Safe Routes project areas, the study control areas, and in California as a whole, consistent with national data. When compared with the control areas, though, the Safe Routes project areas did not show a greater decline in the number of injuries. However, once increases in walking rates were taken into account in the project areas, the California program did suggest a decreased rate of injury and a net benefit in terms of safety for affected students. Other reported safety benefits include reductions in near misses, increased perceptions of safety, less vehicle traffic, and improved driver and pedestrian behaviour (*21*).

EVALUATION METHODOLOGY AND MAJOR FINDINGS

This present study was conducted with a grant from the Robert Wood Johnson Foundation Active Living Research Program. Researchers from UCB updated the safety study (21) and two members of the original UCI research team conducted the mobility study (22, 23). 47 schools throughout California were included in the safety study, and 9 schools from Southern California were included in the mobility study.

The goals of this SRTS evaluation were to:

1. Assess the long-term impact of *safety* around schools that have implemented SRTS-funded infrastructure improvements around schools.
2. Assess the long-term impact of SRTS-funded engineering modifications on walking and bicycling *activity*.

The focus of this research was to develop analyses that were location-specific; i.e., we looked at safety and mobility near where specific SRTS infrastructure improvements were made. Overall, this method provides a model for future evaluation research. Methodology and major findings are described separately below for safety and mobility.

Safety Study

Methodology

The safety analysis is based on a comparison of school areas that were affected by SRTS projects (school areas), and nearby areas that were unlikely to be affected by the SRTS improvements (control areas). For both the school areas and the control areas, the change in the number of collisions was compared for the period before the SRTS construction took place (pre-construction) and the period after the SRTS construction was completed (post-construction). This location-based analysis required compiling data from several sources: agencies, schools, and the location of SRTS funded countermeasures and collision data.

Program data

Data on funded agencies was available from the California Department of Transportation (Caltrans). SRTS website. Follow-up contacts to individual agencies provided information on the schools affected by the project, locations of constructed countermeasures and construction start and end dates. 313 agencies were contacted through email. 93 agencies responded to the request for data.

School data

Program data is available at the agency level. A SRTS program can affect one or multiple schools. Each school listed in an agency's application was matched to the California Department of Education's database of public schools. The database has information on each school related to enrollment, grade level, opening dates, latitude/longitude coordinate and other factors. Each school is assigned a County-District-School (CDS) code and this is used as a unique identifier to match all schools used in the analysis.

Countermeasure data

A funded project at a school site can list zero, one or multiple countermeasures. For example, a SRTS project could fund the construction of sidewalks, curb ramps and radar speed feedback signs for a school. Also, one countermeasure could affect multiple schools: for example a project could fund the construction a sidewalk expansion that affects two schools that are close to each other. Some project data did not specify the location of the countermeasure.

Countermeasures were classified as being located either at an intersection or along a corridor. A countermeasure dataset was created that had one record per countermeasure per school. The dataset was then geocoded using a combination of ArcGIS software and Google Maps. Intersections were batch-geocoded using ArcGIS 10 and Streetmap North America. Corridors were initially created using Google My Maps by tracing the roadway between the specified start and end points. The corridors were then imported into ArcGIS software. A buffer of 250 feet (76.2 meters) was created around each countermeasure. Previous research by the Florida DOT and Federal Highway Administration (FHWA) used the same buffer measurement (24, 25). It was determined that collisions within 250 feet of a countermeasure could reasonably be expected to be affected by the countermeasure.

When available, the expected effectiveness of SRTS infrastructure improvements was gauged by consulting the FHWA guide for Crash Reduction Factors (CRFs). Table 1 summarizes the CRFs for the countermeasures in the final dataset. CRF is a number giving the expected percentage reduction in collisions for a particular countermeasure. For example, among the set of infrastructure countermeasures identified in this study, that with the highest CRF is "Install sidewalk (to avoid walking along roadway)", with the CRF = 74. (Table 1) This means that there is a 74 percent expected reduction in pedestrian involved collisions for that countermeasure. Applying this research to the SRTS evaluation, it is expected that countermeasures with high CRFs would yield a safety benefit. With this evaluation, the purpose of applying CRFs was to determine whether, a priori, the installed infrastructure improvements had a demonstrated effectiveness based on previous systematic studies.

The dataset of geocoded countermeasure buffer zones included 25 corridors and 50 intersections.

TABLE 1 Countermeasures and Crash Reduction Factors in Dataset

Countermeasure	Count	CRF
Install sidewalk (to avoid walking along roadway)	25	74
Install traffic signal	11	38
Install dynamic advance intersection warning system	2	70
Install flashing beacons as advance warning	1	30
Replace existing WALK / DON'T WALK signals with pedestrian countdown signal heads	2	52
Install speed humps	3	50
Install changeable speed warning signs for individual drivers	4	46
Improve super elevation (for drainage)	7	45
	55	

Pre and Post Construction Dates

Each program area was assigned a pre-construction and a post-construction period based on the construction start and end dates provided by agencies. The pre-construction start date was designated as the later date of either the date the school opened or 48 months before the end date. The pre-construction end date was the reported date that construction started. The start date for the post-construction period was the reported date of construction completion. The end date was selected as the earliest of 48 months after the start date, the date the school closed, or December 31, 2009.

Collision Data

Collision data was obtained from the California Statewide Integrated Traffic Records System (SWITRS, *30*). SWITRS is a database of police-reported collisions maintained by the California Highway Patrol. These collisions were subsequently geocoded and then made accessible to researchers through the Transportation Injury Mapping System (TIMS, *31*). SWITRS Injury and fatality data were obtained from TIMS for the period of January 1, 1998 through December 31, 2009. Pedestrian or bicycle involved collisions occurring between 6 a.m. and 6 p.m. from September through May were selected for the analysis.

Dataset of Localized Collisions

Collisions occurring within 250-foot countermeasure buffer zones (program areas) or a quarter-mile school buffer zones (control areas) were selected for the statistical analysis. A binary variable was created that described location: either within the improvement zone (program area) or outside the improvement zone (control area). The sample was stratified by school using a numeric code (1 through 75).These represented 150 program and control areas around 75 constructed countermeasures. 32 of these were intersection based and 15 were corridor based countermeasures. These countermeasures were localized to 47 schools: the breakdown of schools within the sample is presented in table 2. A school could appear multiple times in the dataset if multiple countermeasures were constructed around it.

Table 2: Schools in Dataset

Grades Served	Number of Schools
Kindergarten- Grade 4	1
Kindergarten – Grade 5	24
Kindergarten – Grade 6	11
Kindergarten – Grade 7	1
Kindergarten – Grade 8	2
Grade 6 - Grade 8	4
Grade 6 - Grade 9	1
Grade 9 - Grade12	3
	47 schools

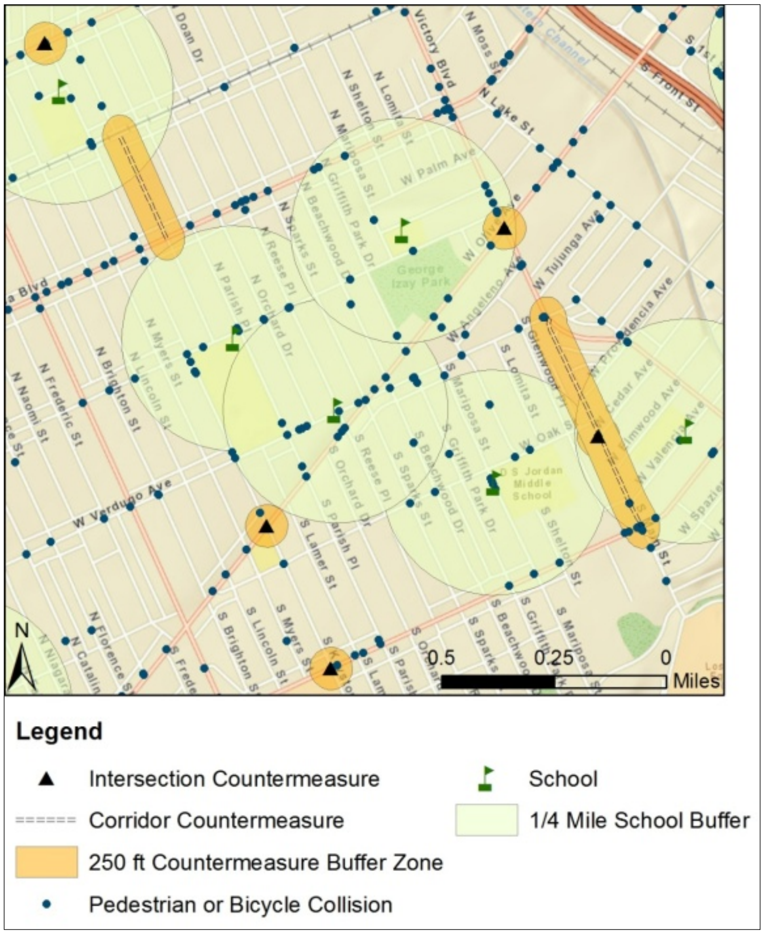
Analysis

We applied random-intercept Poisson and random-intercept negative binomial regression models to the data, using methods discussed in (*26, 27, 28*) The Stata statistical software package (*29*) was used for all data management and analysis procedures and the gllamm (generalized linear latent and mixed models) procedure was used to implement the models. A Huber-White sandwich estimator of the variance-covariance matrix was specified to protect against violations of distributional assumptions. Over dispersion is a common problem with Poisson regression. The random intercept as well as the robust variance estimator was used to address the over dispersion

Major Findings

Upon mapping these locations, it was clear that (i) On an average, the intersections were within 0.23 miles (0.37kms) of the nearest school, and (ii) collisions were often situated in locations that were unlikely to be affected by the SRTS infrastructure improvements. (Figure 1)

FIGURE 1 Sample SRTS Injury Collision and SRTS Countermeasure Map (Los Angeles, CA)



As mentioned above, this analysis focused on changes in numbers of injury collisions that occurred ***within*** 250 feet of the funded countermeasure. These injury collisions were then compared to changes in the numbers of injury collisions that occurred ***beyond*** 250 feet of the countermeasures but within a quarter mile of the school. This approach was based on the assumption that countermeasures would affect pedestrian and/or bicyclist safety closest to their installation location. Countermeasures would not be expected to affect pedestrians/bicyclists arriving outside their range. For example, if a sidewalk were built on the east side of a school, those living on the west side would not be expected to benefit from it on the trip to school. The analysis was conducted twice: first, for pedestrians/bicyclists ages 5 to 18 and second, for pedestrians/bicyclists of all ages.

For the first analysis, collisions involving pedestrians/bicyclists ages 5 to 18, an incident rate ratio (IRR) of 0.47 was found, corresponding roughly to a 50% reduction in collisions in the treatment area (within 250 feet of the countermeasure) in relation to the area outside the treatment area. However, the effect did not reach the statistically significant level of 0.05. The patterns for sub-categories of injuries were similar.

For the second analysis, collisions involving pedestrians/bicyclists of all ages, the IRR was 0.26, corresponding to a collision reduction of about 75%, and was highly statistically significant. The pattern was similar for most of the collisions sub-categories. While the primary rationale for the SRTS program is increasing safety for students on their way to and from school, countermeasures for increasing safety for students also improve safety for pedestrians/bicyclists of all ages.

TABLE 3 Incidence Rate Ratios for Program Effect, by Collision and School Characteristics of Pedestrian or Bicycle Collisions among Children Ages 5 to 18, for 47 Schools Within 250 Feet of Improvements

Collision Characteristics	IRR	95% LL	95% UL	p
Total	0.47	0.20	1.12	0.09
Fatal or severe injury	0.35	0.03	3.63	0.38
Minor injury	0.68	0.34	1.39	0.29
Morning (6-9 a.m.)	0.59	0.17	2.10	0.42
Afternoon (3-6 p.m.)	0.45	0.10	2.00	0.30
Elementary	0.44	0.14	1.39	0.16
Middle	0.93	0.23	3.70	0.91
High School	0.15	0.01	1.84	0.14

TABLE 4 Incidence Rate Ratios for Program Effect, by Collision and School Characteristics of Pedestrian or Bicycle Collisions Among All Ages, at 47 Schools Within 250 Feet of Improvements

Collision Characteristics	IRR	95% LL	95% UL	p
Total	0.26	0.11	0.63	0.003
Fatal or severe injury	0.15	0.01	1.85	0.14
Minor injury	0.27	0.12	0.63	0.003
Morning (6-9 a.m.)	0.56	0.17	1.87	0.34
Afternoon (3-6 p.m.)	0.09	0.02	0.45	0.004
Elementary	0.36	0.13	1.09	0.05
Middle	0.15	0.02	1.42	0.10
High School	0.12	0.02	0.76	0.02

The strengths of this analysis are (i) high case ascertainment: using police reported collisions in SWITRS, and (ii) pre-post comparison of collisions within the distance of countermeasure impact. The safety portion of the study involved the development of analyses that were more appropriate for the specific location-based SRTS infrastructure improvements in comparison with the school wide analyses that were conducted in our previous study (*20*).

Studying Mode Shift

This study also included measuring the impact of ten years of the SRTS program in California on walking and bicycling, and whether infrastructure improvements funded through the program encouraged children to walk to school. A parent survey form developed by the National Center for Safe Routes to School (*33*) was used to collect data on mobility and to determine reported barriers to walking to school.

The survey was administered at eight of the original 16 schools that participated in earlier evaluations of SRTS, and participating schools distributed the parent survey forms to all students. Eight schools participated in this evaluation. A total of 1999 forms were returned from the eight schools.

The collision analysis examined the effect of the SRTS constructed countermeasures on safety at locations that would be directly impacted by their construction. The parent surveys indicate the distance and travel mode to school. They also indicate the nearest intersection closest to the family residence. The research team identified and geocoded SRTS funded countermeasures near each of the eight schools, and then geocoded the intersection information from the parent surveys and calculated the distance between the household and the SRTS countermeasure. The probability of walking to school was compared for households that lived within 250 feet of the countermeasure versus households that lived further than 250 feet but less than a quarter mile from school. Analysis found that living within 250 feet of an SR2S project increased the probability that a child walked to school (coefficient = 0.82, Z statistic=2).

Parents Perceptions of the Safety of Walking and Bicycling: The parent surveys showed that parents generally agreed that (i) walking and biking to school are beneficial to their children's health, but that (ii) there were significant barriers in terms of distance, built environment, and risk. Non-infrastructural improvements that include encouragement activities and adult supervision of children, such as walking school buses, crossing guards, and higher levels of enforcement, are showing positive effects in encouraging walking.

Implications for Evaluation of Safety in Future SRTS Programs

Buffer zones for evaluation: We observed that installed countermeasures were spatially very limited and often located some distance from the school, and therefore not expected to have an impact on the entire area around the school. One of our most important conclusions is that changes to the infrastructure should be evaluated within the area in which the countermeasure is expected to have an impact. Previous analyses (*22, 23*), suggest using a much wider buffer zone. This breadth would be appropriate for programs that include systemic approaches; e.g., education, enforcement, area wide speed limits, that might be expected to have impacts on the entire area surrounding a school.

Data on infrastructure improvements: Data on the installation of infrastructure improvements is critical; however, this information was only available for a subset of the funded projects. In future programs, systematic reporting on infrastructure improvements (type, timing etc.) should be a condition of funding. The United States Government Accountability Office discussed the importance of conducting program evaluation of the Federal safe routes to school program in their report on the implementation of Safe Routes to School (*32*).

Time of analysis: The initial analyses were limited to pedestrians/bicyclists ages 6-18 and between the hours of 6 a.m. and 6 p.m. from September through May. Countermeasures would be expected to have a positive impact beyond those age and time categories.

Age range of observations: In addition to a focus on students and periods of school operation, future analyses should also include pedestrians/bicyclists of other ages and other time spans to assess the full impact of the funded countermeasures.

Statistical methods: The analyses conducted for a pre-post evaluation of SRTS projects are by necessity a quasi-experimental design, subject to bias by regression to the mean effects. To address this, evaluators should be collect sufficient data and conduct Bayesian analyses to control, as much as possible, for regression to the mean effects.

LIMITATIONS

The project encountered four major challenges:

1. In the case of the mobility analysis, despite a $1,000 incentive to the school and repeated attempts to contact administrators, only eight schools that fit the criteria for use in the analyses participated. To increase participation, the response deadline for schools was extended, and substantial outreach was undertaken to encourage school participation.
2. The mobility analysis used self-reported data from the parent survey to identify the location of the household from the constructed countermeasure. 25% of the total 1999 reported intersections from the parent survey forms could not be geocoded. The intersections were either incorrectly identified or were actually parallel streets. Though the regression found that children living closer to the countermeasure were more likely to walk to school, we caution that the sample size was small: only 125 households. The mode to school is also self reported in the parent survey. This is not a good substitute for actual counts of how children arrive at school using different modes.
3. In the case of the safety analysis, it was also difficult to get a strong response rate from the funded agencies (departments of transportation and public works) for information on infrastructure improvements, despite repeated emails and calls to each agency. One reason for the lack of response may be that agencies have a degree of turnover, making it difficult to contact the appropriate person to get information about the SRTS grants written, and the projects implemented. While it was difficult reaching many agencies, the local agencies that did respond were quite helpful, and the evaluation could not have been conducted without their input.
4. Regarding the data analysis, it was apparent that participating agencies need to collect more reliable and consistent data about the programs they fund. While proposed funding information was available, it was unclear without agency response whether they actually deployed the proposed improvements, or selected others. Part of the difficulty in evaluating the program is that agencies are under no obligation to report which improvements were actually deployed. To improve evaluations in the future, agencies could be required to pinpoint exact construction locations on a map. While the questionnaire could be modified to obtain this specific information, data would still be limited to those agencies which responded.

Further, schools and improvements for which there is available data may not be representative of the entire program. Another weakness, explored in further detail below, is the possibility of a regression to the mean phenomenon influencing the findings. Specifically, insofar as infrastructure locations are influenced by the occurrence of crashes; i.e., statistically high crash location, a regression to the mean effect might result in reduced observed crashes following countermeasure installation even if the countermeasure had no impact. In other words, regression to the mean refers to the fact that a crash at one intersection does not necessarily mean there will be crashes there every year hence. Installing a countermeasure may affect safety, or, may have had no effect since, regardless of the countermeasure, there may be any more crashes at that location. Statistical techniques, such as an Empirical Bayes approach, may be a partial remedy for correcting this potential bias. Such an analysis is outside the scope of this study given the data involved, but the approach is recommended in future studies of safety in SRTS programs.

CONCLUSIONS

Safe Routes to School programs hold much appeal as an effective way to increase both safety and walking/bicycling to school. Positive results for safety and mobility, as well as improved data collection for funded programs, should make SRTS programs competitive among other transportation needs. Understanding the potential for walking to school can help identify appropriate countermeasures, and can also help with evaluation of safety and mode shift.

Substantial funds have been allocated to SRTS programs across the country. While evaluation has measured changes in mobility and perceived safety, few evaluations have been able to quantify the effect on safety. The National Center for Safe Routes to School, in their Federal Safe Routes to School Evaluation Plan (*27*), recommends the use of three evaluation components that can help evaluate the extent to which changes in walking and bicycling and safety occur:

1. Documenting state program processes
2. Monitoring implementation of projects and overall walking and bicycling trends
3. Conducting project effectiveness studies

Crash outcomes are the recommended long-term outcome measure for safety, and may affect walking and bicycling. The development of methods to evaluate the impact of infrastructures mirrors what has been established for vehicle safety and volume, and is necessary in competing against these programs for limited transportation dollars. Not only can this inform funding of programs, it can also support public policy efforts to promote active transportation with scientific evidence. The lack of quantifiable results has limited the establishment of active transportation programs, and funding for programs that compete with traditional transportation safety programs. Evidence from this research can contribute substantially to the field.

LIST OF TABLES AND FIGURES

Tables

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